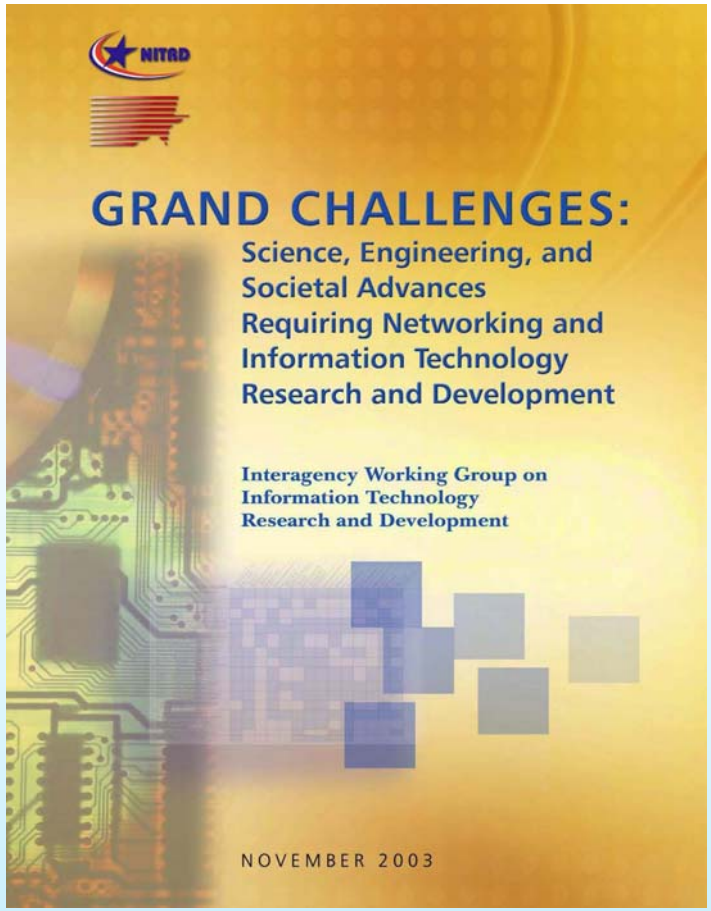
Grand Challenges in Networking and Information Technology Research and Development (NITRD)



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March 4, 2004

Why Have Grand Challenges?

- To explain why NITRD is important to society
- To justify why public expenditures are worthwhile for NITRD
- To galvanize the NITRD agencies and the research community to solve underlying IT hard problems

What Is a Grand Challenge?

- A Grand Challenge (GC) is a long-term science, engineering, or societal advance, whose realization requires innovative breakthroughs in Information Technology Research and Development (IT R&D), and which will help address our country's priorities.

In FY 2003, the NITRD GCS Task Force Identified a List of Our Country's National Priorities (NPs)

- NPs reflect our country's broad-based scientific, military, social, economic, and political values and goals
- Six NPs were identified in consultation with OSTP
  - Leadership in Science and Technology
  - National and Homeland Security
  - Health and Environment
  - Economic Prosperity
  - A Well-Educated Populace
  - A Vibrant Civil Society

The Task Force Then Linked the NPs to a Newly Identified Set of GCs

- 16 illustrative GCs were identified associated with 11 NITRD agencies
- The GCs are illustrative and not definitive or exhaustive because they were proposed largely by technical communities
  - Others could be identified

The 16 NITRD Illustrative GCs

- Knowledge Environments for Science and Engineering
- Clean Energy Production Through Improved Combustion
- High Confidence Infrastructure Control Systems
- Improved Patient Safety and Health Quality
- Informed Strategic Planning for Long-Term Regional Climate Change
- Nanoscale Science and Technology: Explore and Exploit the Behavior of Ensembles of Atoms and Molecules
- Predicting Pathways and Health Effects of Pollutants
- Real-Time Detection, Assessment, and Response to Natural or Man-Made Threats
- Safer, More Secure, More Efficient, Higher-Capacity Multi-Modal Transportation System
- Anticipate Consequences of Universal Participation in a Digital Society
- Collaborative Intelligence: Integrating Humans with Intelligent Technologies
- Generating Insights From Information at Your Fingertips
- Managing Knowledge-Intensive Organizations in Dynamic Environments
- Rapidly Acquiring Proficiency in Natural Languages
- SimUniverse: Learning by Exploring
- Virtual Lifetime Tutor for All

The Task Force Also Linked the GCs to Information Technology Hard Problem (ITHP) Areas

- ITHP Areas are broad categories of topics of interest to the IT R&D community and reflect the breadth of the NITRD Program
- Advances in the ITHP Areas must be achieved in order to solve these GCs
- 14 ITHP Areas were identified:

♦Algorithms and Applications
♦Complex Heterogeneous Systems
♦Hardware Technologies
♦High Confidence IT
♦High-End Computing Systems
♦Human Augmentation IT
♦Information Management
♦Intelligent Systems
♦IT Systems Design
♦IT Usability
♦IT Workforce
♦Management of IT
♦Networks
♦Software Technologies

Relationships Between the Illustrative GCs and the NPs

ILLUSTRATIVE GRAND CHALLENGES	NATIONAL PRIORITIES: Leadership in Science and Technology	National and Homeland Security	Health and Environment	Economic Prosperity	A Well-Educated Populace	A Vibrant Civil Society
Knowledge Environments for Science and Engineering	■	■	■		■	■
Clean Energy Production Through Improved Combustion	■	■	■	■		
High Confidence Infrastructure Control Systems		■		■		■
Improved Patient Safety and Health Quality			■	■		
Informed Strategic Planning for Long-Term Regional Climate Change	■		■	■	■	
Nanoscale Science and Technology: Explore and Exploit the Behavior of Ensembles of Atoms and Molecules	■	■	■	■		
Predicting Pathways and Health Effects of Pollutants	■	■	■	■		
Real-Time Detection, Assessment, and Response to Natural or Man-Made Threats		■	■	■		
Safer, More Secure, More Efficient, Higher-Capacity Multi-Modal Transportation System			■	■		
Anticipate Consequences of Universal Participation in a Digital Society	■	■	■	■	■	■
Collaborative Intelligence: Integrating Humans with Intelligent Technologies	■	■	■	■	■	■
Generating Insights From Information at Your Fingertips	■	■	■	■		
Managing Knowledge-Intensive Organizations in Dynamic Environments		■	■	■		
Rapidly Acquiring Proficiency in Natural Languages	■	■			■	■
SimUniverse: Learning by Exploring	■		■	■	■	
Virtual Lifetime Tutor for All				■	■	■

Relationships Between the Illustrative GCs and the ITHP Areas

ILLUSTRATIVE GRAND CHALLENGES	IT HARD PROBLEM AREAS: Algorithms and Applications	Complex Heterogeneous Systems	Hardware Technologies	High Confidence IT	High-End Computing Systems	Human Augmentation IT	Information Management	Intelligent Systems	IT System Design	IT Usability	IT Workforce	Management of IT	Networks	Software Technologies
Knowledge Environments for Science and Engineering	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Clean Energy Production Through Improved Combustion	■				■		■					■		
High Confidence Infrastructure Control Systems		■		■									■	
Improved Patient Safety and Health Quality	■			■		■	■	■	■	■		■	■	■
Informed Strategic Planning for Long-Term Regional Climate Change	■		■	■	■	■	■	■	■	■	■	■	■	■
Nanoscale Science and Technology: Explore and Exploit the Behavior of Ensembles of Atoms and Molecules	■		■		■	■			■				■	
Predicting Pathways and Health Effects of Pollutants	■	■		■	■	■	■	■		■	■		■	■
Real-Time Detection, Assessment, and Response to Natural or Man-Made Threats	■	■			■	■	■	■					■	
Safer, More Secure, More Efficient, Higher-Capacity Multi-Modal Transportation System	■	■		■			■	■	■	■		■	■	■
Anticipate Consequences of Universal Participation in a Digital Society	■	■		■	■	■	■	■	■	■	■	■	■	■
Collaborative Intelligence: Intergrating Humans with Intelligent Technologies	■	■		■		■	■	■	■	■	■	■	■	■
Generating Insights From Information at Your Fingertips		■		■			■	■		■			■	
Managing Knowledge-Intensive Organizations in Dynamic Environments	■	■		■	■	■	■	■	■	■	■	■	■	■
Rapidly Acquiring Proficiency in Natural Languages	■	■				■	■	■		■				
SimUniverse: Learning by Exploring	■					■			■	■				■
Virtual Lifetime Tutor for All	■					■	■	■	■	■				

Example Grand Challenge: High Confidence Infrastructure Control Systems

- Description of the Multi-Decade Grand Challenge
  - Ensure the continuous, safe operation of the Nation's infrastructure systems (e.g., power grid, water supply, transportation system), and protect against malicious attacks and physical and complex cascading failures
- Focus for the Next Ten Years
  - Supervisory Control and Data Acquisition (SCADA) systems, transformation from legacy systems to IT-enabled infrastructures, and coordinated decentralized control of new forms of distributed infrastructure (e.g., air traffic control, transportation scheduling)
- Benefits
  - Robust, survivable, attack and failure proof infrastructures, higher capacity systems, and the reduction of failures
- Relationship to National Priorities
  - National Security, Homeland Security, Economic Prosperity, and a Vibrant Civil Society
- IT Hard Problem Areas
  - See the next slide (#10)
- Indications of Progress
  - Reduction in mean time to recovery (MTTR), and fewer and smaller scale failures

IT Hard Problem Areas for High Confidence Infrastructure Control Systems

- Complex Heterogeneous Systems
  - Understand, control, and successfully react to simultaneous conflicting interactions (e.g., fault tolerance, time-sensitive recovery, maintenance of security while recovering), and to emerging, hard-to-predict behavior in SCADA systems
- High Confidence IT
  - Integrate security (e.g., authentication, access control, intrusion detection) into networked embedded systems, and continue operating through attacks without shutting down
- Networks
  - Secure and survivable networks